General

Guideline Title

Effectiveness of practices to reduce blood culture contamination: a Laboratory Medicine Best Practices systematic review and meta-analysis.

Bibliographic Source(s)

Snyder SR, Favoretto AM, Baetz RA, Derzon JH, Madison BM, Mass D, Shaw CS, Layfield CD, Christenson RH, Liebow EB. Effectiveness of practices to reduce blood culture contamination: a Laboratory Medicine Best Practices systematic review and meta-analysis. Clin Biochem. 2012 Sep;45(13-14):999-1011. [45 references] PubMed

Guideline Status

This is the current release of the guideline.

This guideline meets NGC's 2013 (revised) inclusion criteria.

Recommendations

Major Recommendations

Definitions for the ratings of overall strength of evidence and recommendation categories are provided at the end of the "Major Recommendations" field.

Conclusions and Recommendations

On the basis of a high overall strength of evidence of effectiveness, venipuncture is recommended as a best practice to reduce blood culture contamination (false positive) rates in all hospital settings. The high overall strength of evidence rating is due to sufficient evidence of practice effectiveness from nine individual studies, all favoring venipuncture over catheter blood collection and demonstrating consistent and substantial reductions in blood culture contamination rates (mean odds ratio [OR] of 2.69; 95% confidence interval [CI]: 2.03–3.57).

On the basis of a high overall strength of evidence of effectiveness, phlebotomy teams are recommended as a best practice to reduce blood culture contamination (false positive) rates in all hospital settings. The high overall strength of evidence rating is due to sufficient evidence of practice effectiveness from five individual studies, all favoring phlebotomy team over non-phlebotomist staff collection and demonstrating consistent and substantial reductions in blood culture contamination rates (mean OR of 2.58; 95% CI: 2.07–3.20).

On the basis of an insufficient overall strength of evidence of effectiveness, no recommendation is made for or against prepackaged prep kits. The overall insufficient strength of evidence rating is based on evidence that indicates inconsistent and unlikely improvement in blood culture (false positive) contamination rates compared to venipuncture collections without prep kits in hospital settings from the results of seven trials in a broad range of hospital settings by multiple types of staff. For six of the seven studies, the prep kit failed to significantly reduce blood culture

contamination relative to a standard practice, and the overall effect size was homogeneous and not statistically significantly different from collections without prep kits (mean OR of 1.12; 95% CI: 0.94–1.35).

Definitions

Overall Strength of Evidence Ratings

The revised definitions for these categories, modeled after the US Preventive Services Task Force (2008) are as follows:

High: An adequate volume of evidence is available and includes consistent evidence of substantial healthcare quality changes from studies without major limitations.

Moderate: Some evidence is available and includes consistent evidence of substantial healthcare quality changes from without major limitations.

Suggestive: Limited evidence is available and includes consistent evidence of moderate healthcare quality changes from a small number of studies without major limitations; OR the quality of some of the studies' design and/or conduct is limited.

Insufficient: Any estimate of an effect is very uncertain. Available evidence of effectiveness is:

- Inconsistent or weak; OR
- Consistent but with a minimal effect; OR
- Contained in an inadequate volume to determine effectiveness

Recommendation Categories

The recommendation rating categories are consistent with the Grading of Recommendations Assessment, Development and Evaluation (GRADE) group findings (2008) and reflect the extent to which the available evidence gives one confidence that a practice will do more good than harm.

Recommend: The practice should be identified as a best practice for implementation in appropriate care settings, taking into account variations in implementation and/or care settings. This recommendation results from consistent and high or moderate overall evidence of effectiveness strength rating of desirable impacts.

No recommendation for or against: The potentially favorable impact on care outcomes and/or error reduction is not sufficient, or not sufficiently supported by evidence to indicate that it should be identified as a best practice for implementation in appropriate care settings. Additional studies may be warranted to strengthen the relevant evidence base. This recommendation results from insufficient evidence to determine effectiveness.

Recommend against: The practice should not be identified as a best practice for implementation because of consistent evidence of adverse effects.

Clinical Algorithm(s)

None provided

Scope

Disease/Condition(s)

Blood stream infections, including septicemia or sepsis

Guideline Category

Diagnosis

Prevention

Technology Assessment

Clinical Specialty

Critical Care

Infectious Diseases

Internal Medicine

Nursing

Pathology

Intended Users

Advanced Practice Nurses

Allied Health Personnel

Clinical Laboratory Personnel

Hospitals

Nurses

Physician Assistants

Physicians

Guideline Objective(s)

- To systematically review the effectiveness of three practices for reducing blood culture contamination rates: venipuncture, phlebotomy teams, and prepackaged preparation/collection (prep) kits
- To evaluate evidence of these practices' effectiveness at reducing blood culture contamination (false positive) rates by applying the Centers for Disease Control and Prevention (CDC) Laboratory Medicine Best Practices Initiative (LMBP) systematic review methods for quality improvement practices and translating the results into evidence-based guidance

Target Population

All patients in healthcare settings who have a blood culture specimens collected

Interventions and Practices Considered

1. Venipuncture
2. Use of a phlebotomy team of certified or trained phlebotomists
3. Prepackaged prep kits (no recommendation for or against)

Major Outcomes Considered

Blood culture contamination rate

Methodology

Methods Used to Collect/Select the Evidence

Hand-searches of Published Literature (Primary Sources)

Hand-searches of Published Literature (Secondary Sources)

Searches of Electronic Databases

Searches of Unpublished Data

Description of Methods Used to Collect/Select the Evidence

The question answered by this evidence review is: *What practices are effective for reducing blood culture contamination?* This review question is addressed in the context of an analytic framework for the quality issue of blood culture contamination depicted in Figure 1 in the original guideline document. The relevant PICO elements are:

- Population: all patients in healthcare settings who have a blood culture specimens collected
- Intervention (practice) versus *C*omparison:
    - Venipuncture versus intravenous catheter collection
    - Phlebotomy team versus non-phlebotomist staff collection
    - Prepackaged prep kit versus no prep kit for venipuncture collection
- Outcome: blood culture contamination rate is the direct outcome of interest

The search for studies of practice effectiveness included a systematic search of multiple electronic databases, hand searching of bibliographies from relevant information sources, consultation with and references from experts in the field including members of the expert panel, and by solicitation of unpublished quality improvement studies resulting in direct submissions to the Laboratory Medicine Best Practices Initiative. The literature search strategy and terms were developed with the assistance of a research librarian and included a systematic search in September 2011 of three electronic databases (PubMed, EMBASE and CINAHL) for English language articles from 1995 to 2012 about human subjects. The search contained the following Medical Subject Headings: allied health personnel, blood, blood specimen collection, catheterization, disinfectants, health personnel, laboratory personnel, phlebotomy as well as these keywords: anti-infective agent, local; antisepsis; blood sampling; blood culture; catheter; contaminants; contamination; costs; disinfection; health care cost(s); healthcare personnel; intravenous catheter; microbiology; paramedical personnel; phlebotomists; phlebotomy team; skin; skin decontamination; quality; and venipuncture.

Included studies were considered to provide valid and useful information addressing the review question, with findings for at least one blood culture contamination rate outcome measure. To reduce subjectivity and the potential for bias, all screening, abstraction and evaluation was conducted by at least two independent reviewers, and all differences were resolved through consensus.

Number of Source Documents

The search identified 456 separate bibliographic records that were screened for eligibility to contribute evidence of effectiveness for the three practices (venipuncture, phlebotomy teams, and prepackaged prep kits) with respect to blood culture contamination rate outcomes. After initial screening, 348 of these records were excluded as off-topic, and 87 were excluded for not meeting effectiveness study inclusion criteria (i.e., a study using data evaluating a practice of interest with at least one finding for a relevant blood culture contamination rate outcome measure). A total of 21 full-text studies met the review inclusion criteria. A systematic review flow diagram in Figure 2 in the original guideline document provides a breakdown of the search results. The full-text review and evaluation of the 21 eligible studies (10 venipuncture; 6 phlebotomy team; 6 prep kits), with one evaluating two practices, resulted in excluding 4 studies (1 venipuncture; 1 phlebotomy team; 2 prep kit) for not meeting the minimum required Laboratory Medicine Best Practices Initiative (LMBP) study quality inclusion criteria. Appendix C (see the "Availability of Companion Documents" field) provides a Body of Evidence table for each practice, as well as abstracted and standardized information and study quality ratings in evidence summary tables for each of the 21 eligible studies. Appendix B provides bibliographic reference information for these studies.

A total of 17 studies are included in this review as evidence of practice effectiveness (9 venipuncture; 5 phlebotomy team; 4 prep kits). One published study contained data evaluating 2 practices and another published study contains 4 studies at separate sites resulting in a total of 7 prep kit studies.

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Overall Strength of Evidence Ratings

The definitions for these categories, modeled after the US Preventive Services Task Force (2008), are as follows:

High: An adequate volume of evidence is available and includes consistent evidence of substantial healthcare quality changes from studies without major limitations.

Moderate: Some evidence is available and includes consistent evidence of substantial healthcare quality changes from without major limitations.

Suggestive: Limited evidence is available and includes consistent evidence of moderate healthcare quality changes from a small number of studies without major limitations; OR the quality of some of the studies' design and/or conduct is limited.

Insufficient: Any estimate of an effect is very uncertain. Available evidence of effectiveness is:

- Inconsistent or weak; OR
- Consistent but with a minimal effect; OR
- Contained in an inadequate volume to determine effectiveness

Methods Used to Analyze the Evidence

Meta-Analysis

Systematic Review with Evidence Tables

Description of the Methods Used to Analyze the Evidence

Included studies were considered to provide valid and useful information addressing the review question, with findings for at least one blood culture contamination rate outcome measure. To reduce subjectivity and the potential for bias, all screening, abstraction and evaluation was conducted by at least two independent reviewers, and all differences were resolved through consensus.

The effect size for each study was standardized using its reported data and results to calculate an odds ratio (OR) since the outcome of interest is dichotomous (i.e., blood culture is contaminated or is not contaminated) and the findings for these practices are typically expressed in terms of rates or percentages. The OR compares the intervention practice to the comparison practice, or comparator, in terms of the relative odds of a successful outcome (i.e., no contamination versus contamination). Each study is assigned one of three quality ratings (Good, Fair, Poor) and one of three effect size ratings (Substantial, Moderate or Minimal/None). (Note: The criteria for a substantial effect size rating: OR>2.0 and significantly different from OR=1.0 at p=0.05 [i.e., the lower limit of the 95% confidence interval is >1.0].)

The results from the individual effectiveness studies are aggregated into a practice body of evidence that is analyzed to produce the systematic review results for translation into an evidence-based recommendation (Recommend, No recommendation for or against, Recommend against). Both qualitative and quantitative analyses are used to assess the effect size consistency and patterns of results across studies, and to rate the overall strength of the body of evidence for practice effectiveness (High, Moderate, Suggestive, and Insufficient). The qualitative analysis synthesizes the individual studies to convey key study characteristics, results and evaluation findings summarized in a body of evidence table. The quantitative analysis is provided using meta-analysis of results from similar individual studies to provide a weighted average effect size and 95% confidence interval (CI) estimated using a random-effects model* and presented in a forest plot with the individual studies' and overall mean odds ratios along with their respective 95% confidence interval upper and lower limits. The I^2 statistic is used to estimate the percent of variability associated with between-study differences.

*Random-effects model assumes there is no common population effect size for the included studies and the studies' effect size variation follows a distribution with the studies representing a random sample. This is in contrast to the fixed-effects model which assumes a single population effect size for all studies and that observed differences reflect random variation.

Methods Used to Formulate the Recommendations

Expert Consensus

Description of Methods Used to Formulate the Recommendations

This evidence review followed the Centers for Disease Control and Prevention (CDC)'s Laboratory Medicine Best Practices Initiative (LMBP)'s "A-6 Cycle" systematic review methods for evaluating quality improvement practices. This approach is derived from previously validated methods, and is designed to transparently evaluate the results of studies of practice effectiveness to support evidence-based best practice recommendations. A review team conducts the systematic review including a review coordinator and staff specifically trained to apply the LMBP methods. Guidance on the conduct of the systematic review and draft recommendations is provided by an expert panel including individuals selected for their diverse perspectives and expertise in the review topic, laboratory management and evidence review methods. The results of the evidence review are translated into an evidence-based best practice recommendation by the expert panel for approval by the LMBP Workgroup, an independent, multi-disciplinary group composed of 15 members with expertise in laboratory medicine, clinical practice, health services research and health policy.

The results from the individual effectiveness studies are aggregated into a practice body of evidence that is analyzed to produce the systematic review results for translation into an evidence-based recommendation (Recommend, No recommendation for or against, Recommend against) (see the "Rating Scheme for the Strength of the Recommendations" field).

Recommendations are formulated in accordance with the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group findings to reflect the extent to which one can be confident that following the recommendations will do more good than harm.

Rating Scheme for the Strength of the Recommendations

Recommendation Categories

The recommendation rating categories are consistent with the Grading of Recommendations Assessment, Development and Evaluation (GRADE) group findings (2008) and reflect the extent to which the available evidence gives one confidence that a practice will do more good than harm.

Recommend: The practice should be identified as a best practice for implementation in appropriate care settings, taking into account variations in implementation and/or care settings. This recommendation results from consistent and high or moderate overall evidence of effectiveness strength rating of desirable impacts.

No recommendation for or against: The potentially favorable impact on care outcomes and/or error reduction is not sufficient, or not sufficiently supported by evidence to indicate that it should be identified as a best practice for implementation in appropriate care settings. Additional studies may be warranted to strengthen the relevant evidence base. This recommendation results from insufficient evidence to determine effectiveness.

Recommend against: The practice should not be identified as a best practice for implementation because of consistent evidence of adverse effects.

Cost Analysis

Economic Evaluation

Venipuncture, like catheter collection, is a primary means of blood sample collection for blood cultures; however the cost of this practice has not been evaluated. Four studies of phlebotomy teams included estimated and projected labor costs and healthcare savings (e.g., reduced hospital length of stay, pharmacy and laboratory services) associated with reduced blood culture contamination rates or false positives. Some studies' estimated savings were associated with either a general reduction in blood culture contamination rates or relied on other sources for key cost-related assumptions. All four studies concluded that the healthcare cost savings from reduced contaminated blood cultures exceeded total phlebotomist labor costs, however they did not compare phlebotomist to non-phlebotomist costs (i.e., implies $0 cost for non-phlebotomist labor). Nonetheless, these studies all support a conclusion that phlebotomy teams are not only cost-effective but cost-saving solely based on reduction in blood culture contamination.

Method of Guideline Validation

Not stated

Description of Method of Guideline Validation

Not applicable

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The type of supporting evidence is identified and graded for each recommendation (see the "Major Recommendations" field).

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

- Accurate blood culture results are essential for providing safe, timely, effective and efficient care for patients with serious infections. These procedures also affect healthcare expenses as well as public health tracking and reporting of healthcare acquired infections and bloodstream infection rates for infection control activities.
- Studies reviewed report beneficial outcomes associated with venipuncture performed by phlebotomists in addition to reducing blood culture contamination rates. These benefits include decreased turnaround time for laboratory test results on specimens other than blood cultures; reduced frequency of misidentified and mislabeled specimens; decrease in patient needle-stick bruises; improved quality of specimens; improved working relationships between phlebotomists and nurses; and higher levels of patient satisfaction.

Potential Harms

Venipuncture procedures should be performed using universal precautions, as there are needle-stick injuries and pathogen exposure risks for the phlebotomists or other healthcare staff drawing patient blood samples. Patients are at risk for needle insertion site injury from multiple attempts to obtain blood specimens.

Qualifying Statements

Qualifying Statements

The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention/the Agency for Toxic Substances and Disease Registry (CDC/ATSDR).

Limitations

The Laboratory Medicine Best Practices Initiative (LMBP) systematic review methods are consistent with practice standards for systematic reviews, but all similar methods are imperfect and include subjective assessments at multiple points that may produce bias. Rating study quality depends on consensus assessments that may be affected by rater experience and the criteria used. Publication bias must be considered although this review contains unpublished studies which may help mitigate that bias. The restriction to English language studies to satisfy the requirement of multiple reviewers for each study may also introduce bias. Most of the evidence for this review is from quality improvement studies, thus the primary data have many limitations, including single institution site-specific differences which may affect study results. Many studies were missing information including actual study sample sizes, dates for relevant time periods, and practice implementation and setting characteristics. Several studies were conducted in specific settings within a hospital such as emergency departments, medical intensive care units and academic settings which may not be generalizable to other settings. Individual study comparison group settings were not always identical, therefore potential differences in practice patterns and patient clinical status could influence results.

Several studies included in this review have study periods that are more than ten years old, with three dating to the early 1990s; two for venipuncture; one for phlebotomy teams; and six of the seven prep kit study periods began prior to or in 2000. Five of the nine studies used a paired blood culture sample study design comparing venipuncture and catheter blood samples from the same patient within a pre-defined time limit,

while the other four studies used groupwise comparisons. Although systematic differences are not observed and all nine included studies favored venipuncture, the non-paired design may yield less valid findings when blood culture contamination is affected by patient or setting characteristics. Three of the five phlebotomy team studies used comparison groups of non-phlebotomists performing only venipuncture collections, thereby controlling for the possibility of catheter contamination. Although systematic differences were not observed, it is likely that the results from these three studies were more representative of the practice's true effect size. All five studies favored phlebotomy teams, but the two studies with non-phlebotomist catheter collections in the comparison group may have had a slight upward bias on the meta-analysis mean effect size estimate. Several studies in this review noted study design limitations in terms of phlebotomy teams and non-phlebotomist staff which may have introduced confounding results on reported blood culture contamination rates and effect sizes due to differences in the skill level and training of staff performing venipuncture.

Implementation of the Guideline

Description of Implementation Strategy

Feasibility of Implementation

Venipuncture is feasible in all settings and patient populations with some special patient case exceptions as noted in the applicability section. The evidence reviewed clearly demonstrates the feasibility of adopting phlebotomy teams in a variety of hospital settings. Implementing phlebotomy teams for blood culture collection may require assessment of the availability of currently trained phlebotomist staff in various areas of the hospital settings and possible reorganization of resources. In settings where phlebotomy has been decentralized or eliminated, changes may be instituted to achieve workforce goals. Selected environments where high volumes of blood cultures are initiated at specific hours of the workday may be an excellent starting point for implementation. Phlebotomist salaries and training costs may be perceived as initial barriers to adoption of phlebotomy teams, therefore an assessment of blood culture contamination rates and associated costs within an institution may be helpful to support perceived additional costs for implementing phlebotomy teams compared to using non-phlebotomist staff. Involvement from multiple, relevant departments and leaders within an organization to support implementation will likely be required.

Implementation Tools

Resources

For information about availability, see the *Availability of Companion Documents* and *Patient Resources* fields below.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

Getting Better

Staying Healthy

IOM Domain

Effectiveness

Identifying Information and Availability

Bibliographic Source(s)

Snyder SR, Favoretto AM, Baetz RA, Derzon JH, Madison BM, Mass D, Shaw CS, Layfield CD, Christenson RH, Liebow EB. Effectiveness of practices to reduce blood culture contamination: a Laboratory Medicine Best Practices systematic review and meta-analysis. Clin Biochem. 2012 Sep;45(13-14):999-1011. [45 references] PubMed

Adaptation

Not applicable: the guideline was not adapted from another source.

Date Released

2012 Sep

Guideline Developer(s)

Centers for Disease Control and Prevention - Federal Government Agency [U.S.]

Laboratory Medicine Best Practices - Independent Expert Panel

Source(s) of Funding

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Guideline Committee

Laboratory Medicine Best Practices Blood Culture Contamination Expert Panel

Laboratory Medicine Best Practices Work Group

Composition of Group That Authored the Guideline

Authors: Susan R. Snyder, Battelle Centers for Public Health Research and Evaluation, United States; Alessandra M. Favoretto, Battelle Centers for Public Health Research and Evaluation, United States; Rich Ann Baetz, Battelle Centers for Public Health Research and Evaluation, United States; James H. Derzon, Battelle Centers for Public Health Research and Evaluation, United States; Bereneice M. Madison, Battelle Centers for Public Health Research and Evaluation, United States; Diana Mass, Associated Laboratory Consultants, United States; Colleen S. Shaw, Centers for Disease Control and Prevention, United States; Christopher D. Layfield, Battelle Centers for Public Health Research and Evaluation, United States; Robert H. Christenson, University of Maryland, United States; Edward B. Liebow, Battelle Centers for Public Health Research and Evaluation, United States

Laboratory Medicine Best Practices (LMBP) Blood Culture Contamination Expert Panel Members: Roberta Carey, PhD (Centers for Disease Control and Prevention); Dennis Ernst, MT (ASCP) (Center for Phlebotomy Education); Dana Grzybicki, MD, PhD (University of Colorado Denver); Margret Oethinger, MD, PhD (Providence Portland Medical Center); Stephen Raab, MD, PhD* (University of Washington); Ronald Schifman, MD, MPH (Southern Arizona VA Healthcare System); Ann Vannier, MD* (Kaiser-Permanente); Melvin Weinstein, MD (University of Medicine, Dentistry of New Jersey-Robert Wood Johnson Medical School)

*LMBP Workgroup member.

LMBP Workgroup, 2008–2011: Raj Behal, MD, MPH (Rush University Medical Center); Robert H. Christenson, PhD, DABCC, FACB (University of Maryland Medical Center); John Fontanesi, PhD (University of California, San Diego); Julie Gayken, MT (ASCP) (Regions Hospital); Cyril (Kim) Hetsko, MD, FACP (University of Wisconsin-Madison, Chief Medical Officer, COLA and Trustee, American Medical Association); Lee H. Hilborne, MD, MPH (UCLA David Geffen School of Medicine, President, American Society for Clinical Pathology, RAND, Quest Diagnostics); James H. Nichols, PhD (Baystate Medical Center); Mary Nix, MS, MT(ASCP)SBB (Agency for Healthcare

Research and Quality); Stephen S. Raab, MD (University of Colorado Denver School of Medicine); Milenko Tanasijevic, MD, MBA (Brigham and Women's Hospital, Dana Farber Cancer Institute, Harvard Medical School); Ann M. Vannier, MD (Kaiser Permanente Southern California Regional Reference Laboratories); Ann Watt, MBA, RHIA (The Joint Commission)

Ex-officio Members: Sousan S. Altaie, PhD (Food and Drug Administration); James Cometa (Centers for Medicaid and Medicare Services)

Financial Disclosures/Conflicts of Interest

Members of the Laboratory Medicine Best Practices (LMBP™) systematic review expert panels and Workgroup are asked to provide information about financial, professional or other associations that may represent or appear to be a potential conflict related to the conduct of the LMBP™ systematic evidence reviews. The Centers for Disease Control and Prevention (CDC) LMBP™ staff reviews the conflict of interest disclosures. If a conflict arises in connection with an LMBP™ systematic review or publication, the appropriate disclosure is provided.

Guideline Status

This is the current release of the guideline.

This guideline meets NGC's 2013 (revised) inclusion criteria.

Guideline Availability

Electronic copies: Available from the PubMed Central (PMC) Web site.

Availability of Companion Documents

The following are available:

- Laboratory Medicine Best Practices (LMBP). Effective practices for reducing blood culture contamination in in-patient settings. Atlanta (GA): Centers for Disease Control and Prevention (CDC); 2012 Feb. 3 p. Electronic copies: Available from the Centers for Disease Control and Prevention (CDC) Web site.
- Effectiveness of practices to reduce blood culture contamination: a Laboratory Medicine Best Practices systematic review and meta-analysis. Appendices. Atlanta (GA): Centers for Disease Control and Prevention (CDC); 2012 Feb. 33 p. Electronic copies: Available from the CDC Web site.
- Christenson RH, Snyder SR, Shaw CS, Derzon JH, Black RS, Mass D, Epner P, Favoretto AM, Liebow EB. Laboratory Medicine Best Practices: systematic evidence review and evaluation methods for quality improvement. Clin Chem 2011 Jun;57(6):816-25. Electronic copies: Available from the Clinical Chemistry Web site.
- Snyder S, Liebow E, Shaw C, Black R, Christenson R, Derzon J, Epner R, Favoretto A, John L, Mass D, Patta A, Rose S, Washington M. Laboratory Medicine Best Practices: developing systematic evidence review and evaluation methods for quality improvement phase 3 final technical report. Atlanta (GA): Centers for Disease Control and Prevention (CDC); 2010 May 27. 159 p. Electronic copies: Available from the CDC Web site.

Patient Resources

None available

NGC Status

This NGC summary was completed by ECRI Institute on May 28, 2015. The information was verified by the guideline developer on August 13, 2015.

Copyright Statement

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